US009351006B2

(12) **United States Patent**
Kim et al.

(10) **Patent No.: US 9,351,006 B2**
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(54) **MOVING PICTURE CODING/DECODING METHOD AND APPARATUS**

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(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-Si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/693,070**

(22) Filed: **Apr. 22, 2015**

(65) **Prior Publication Data**

US 2015/0271501 A1 Sep. 24, 2015

Related U.S. Application Data

(63) Continuation of application No. 14/597,627, filed on Jan. 15, 2015, now Pat. No. 9,131,244, which is a continuation of application No. 11/405,420, filed on Apr. 18, 2006, now Pat. No. 8,958,476.

(60) Provisional application No. 60/672,047, filed on Apr. 18, 2005.

(51) **Int. Cl.**
H04N 7/12 (2006.01)
H04N 19/136 (2014.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04N 19/136*** (2014.11); ***H04N 7/26335*** (2013.01); ***H04N 7/50*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . H04N 7/50; H04N 7/26335; H04N 7/26244; H04N 7/26941
USPC 375/240.25, 240.12, 240.26; 382/233, 382/235, 238
See application file for complete search history.

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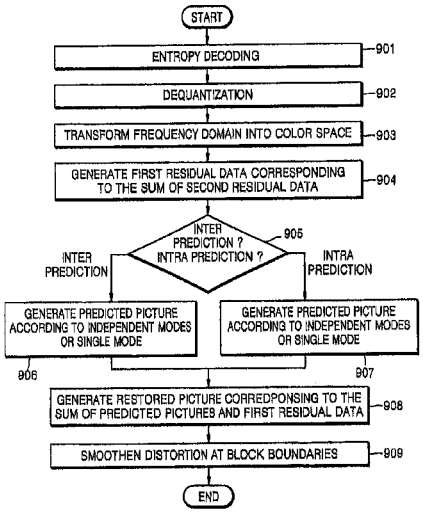
Primary Examiner — Shawn An
(74) *Attorney, Agent, or Firm* — Staas & Halsey LLP

(57) **ABSTRACT**

An image decoding apparatus is provided. The image decoding apparatus includes a processor which obtains information about a color representation from a bitstream, obtains a residue, which corresponds to a difference between a current image and a predicted image of the current image, from the bitstream, and reconstructs the current image by using the residue and the predicted image, based on the information about the color representation.

2 Claims, 14 Drawing Sheets



(51) **Int. Cl.**

H04N 19/186	(2014.01)
H04N 19/105	(2014.01)
H04N 19/50	(2014.01)
H04N 19/503	(2014.01)
H04N 19/176	(2014.01)
H04N 19/119	(2014.01)
H04N 19/172	(2014.01)
H04N 19/61	(2014.01)
H04N 19/593	(2014.01)
H04N 19/11	(2014.01)
H04N 19/103	(2014.01)
H04N 19/107	(2014.01)
H04N 19/109	(2014.01)
H04N 19/117	(2014.01)
H04N 19/44	(2014.01)
H04N 19/86	(2014.01)
H04N 19/00	(2014.01)
H04N 19/139	(2014.01)
H04N 19/159	(2014.01)
H04N 19/85	(2014.01)
H04N 19/91	(2014.01)
H04N 19/51	(2014.01)
H04N 19/60	(2014.01)
H04N 19/40	(2014.01)

(52) **U.S. Cl.**

CPC ***H04N 19/0003*** (2013.01); ***H04N 19/00018*** (2013.01); ***H04N 19/00024*** (2013.01); ***H04N 19/00036*** (2013.01); ***H04N 19/00042*** (2013.01); ***H04N 19/00066*** (2013.01); ***H04N 19/00072*** (2013.01); ***H04N 19/00266*** (2013.01); ***H04N 19/00278*** (2013.01); ***H04N 19/00315*** (2013.01); ***H04N 19/00569*** (2013.01); ***H04N 19/00575*** (2013.01); ***H04N 19/00763*** (2013.01); ***H04N 19/00781*** (2013.01); ***H04N 19/00909*** (2013.01); ***H04N 19/103*** (2014.11); ***H04N 19/105*** (2014.11); ***H04N 19/107*** (2014.11); ***H04N 19/109*** (2014.11); ***H04N 19/11*** (2014.11); ***H04N 19/117*** (2014.11); ***H04N 19/119*** (2014.11); ***H04N 19/139*** (2014.11); ***H04N 19/159*** (2014.11); ***H04N 19/172*** (2014.11); ***H04N 19/176*** (2014.11); ***H04N 19/186*** (2014.11); ***H04N 19/44*** (2014.11); ***H04N 19/50*** (2014.11); ***H04N 19/503*** (2014.11); ***H04N 19/51*** (2014.11); ***H04N 19/593*** (2014.11); ***H04N 19/60*** (2014.11); ***H04N 19/61*** (2014.11); ***H04N 19/85*** (2014.11); ***H04N 19/86*** (2014.11); ***H04N 19/91*** (2014.11); *H04N 7/26244* (2013.01); *H04N 7/26941* (2013.01); *H04N 19/40* (2014.11)

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9,131,244	B2 *	9/2015	Kim	H04N 19/00315
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Office Action mailed Mar. 27, 2015 in related U.S. Appl. No. 14/597,627.

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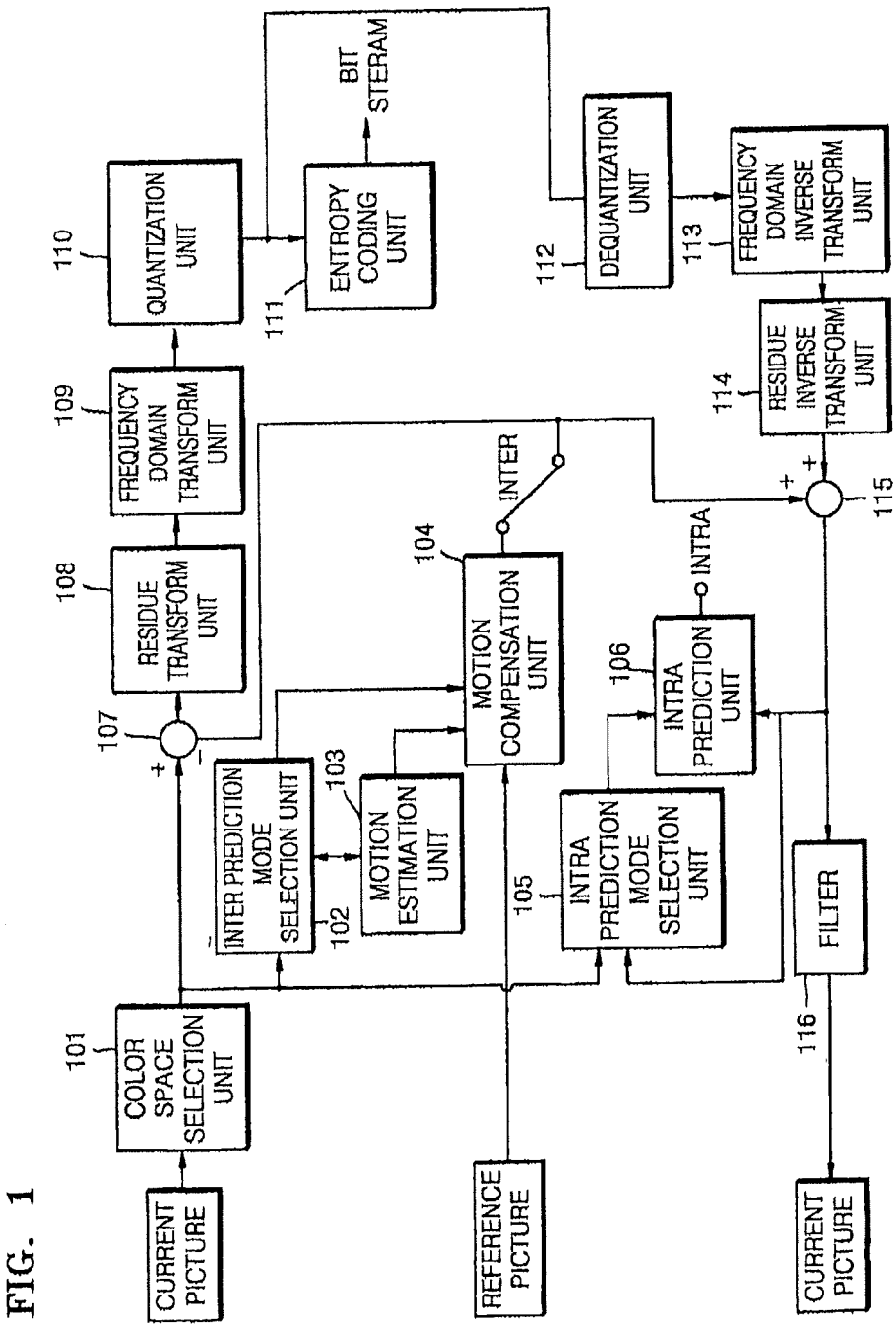
FIG. 1


CURRENT PICTURE
101
COLOR SPACE SELECTION UNIT
107
+
-
RESIDUE TRANSFORM UNIT
108
FREQUENCY DOMAIN TRANSFORM UNIT
109
QUANTIZATION UNIT
110
ENTROPY CODING UNIT
111
BIT STERAM
INTER PREDICTION MODE SELECTION UNIT
102
MOTION ESTIMATION UNIT
103
MOTION COMPENSATION UNIT
104
INTER
INTRA
INTRA PREDICTION UNIT
106
INTRA PREDICTION MODE SELECTION UNIT
105
REFERENCE PICTURE
DEQUANTIZATION UNIT
112
FREQUENCY DOMAIN INVERSE TRANSFORM UNIT
113
RESIDUE INVERSE TRANSFORM UNIT
114
+
+
115
FILTER
116
CURRENT PICTURE

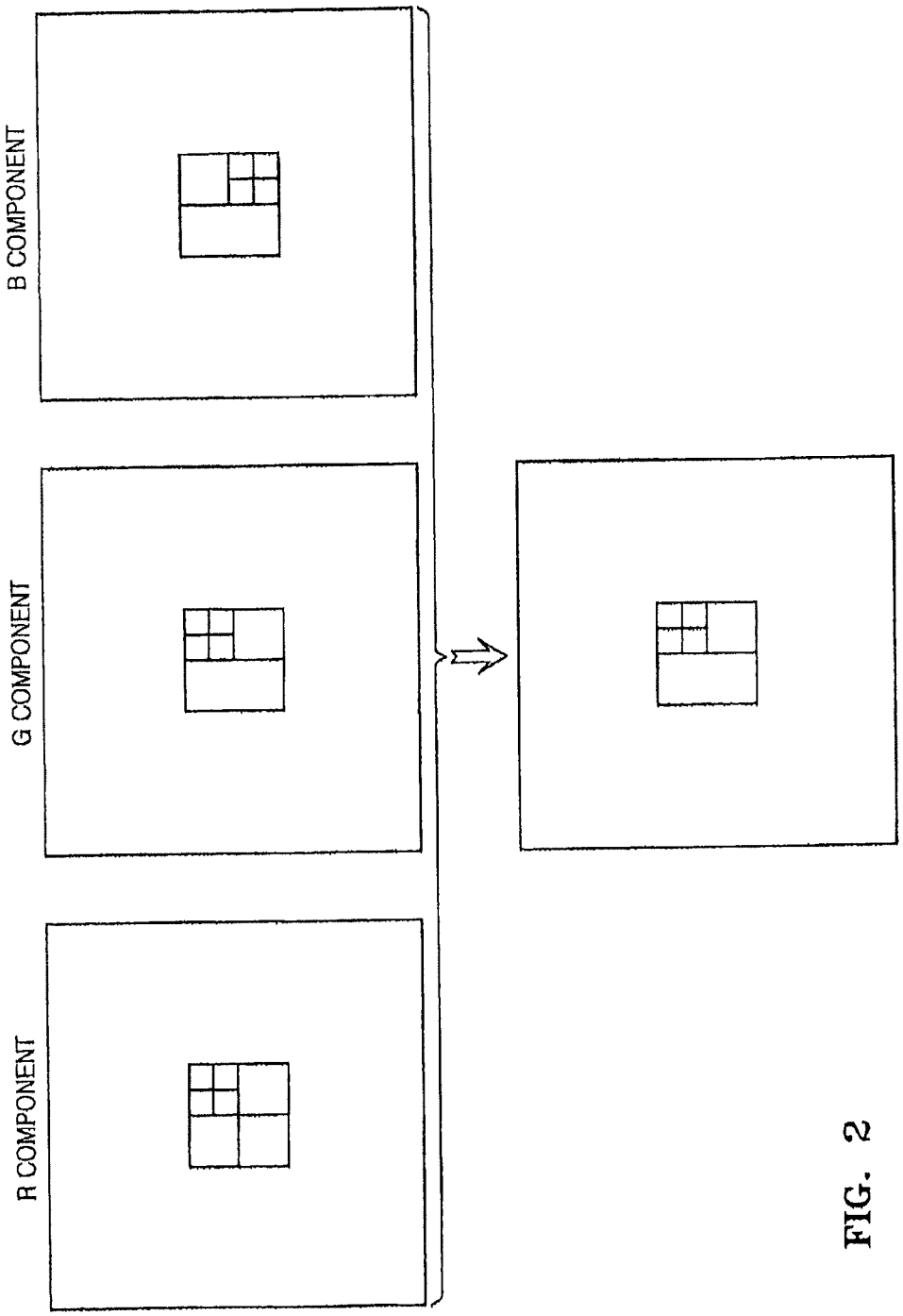


FIG. 2

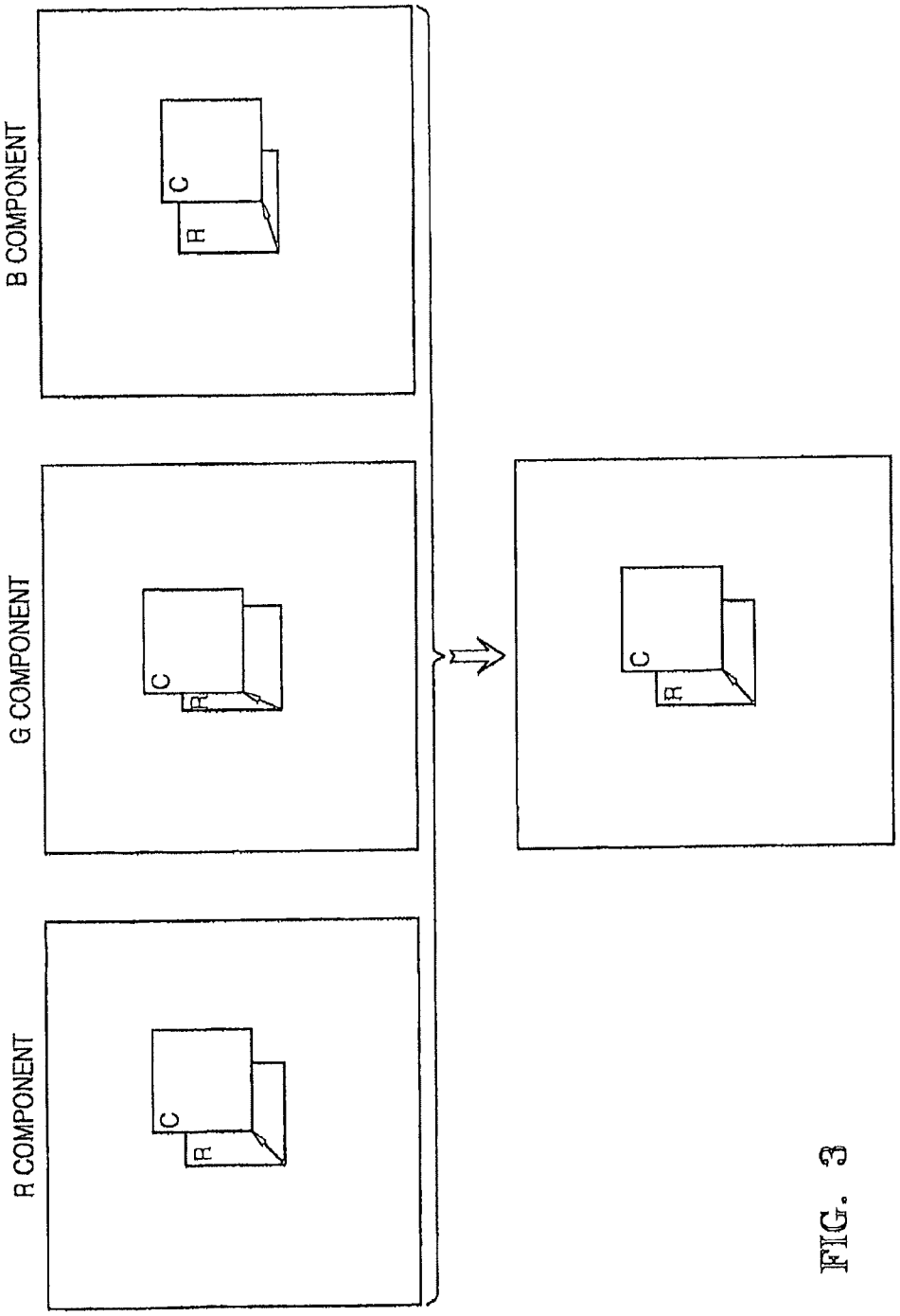


FIG. 3

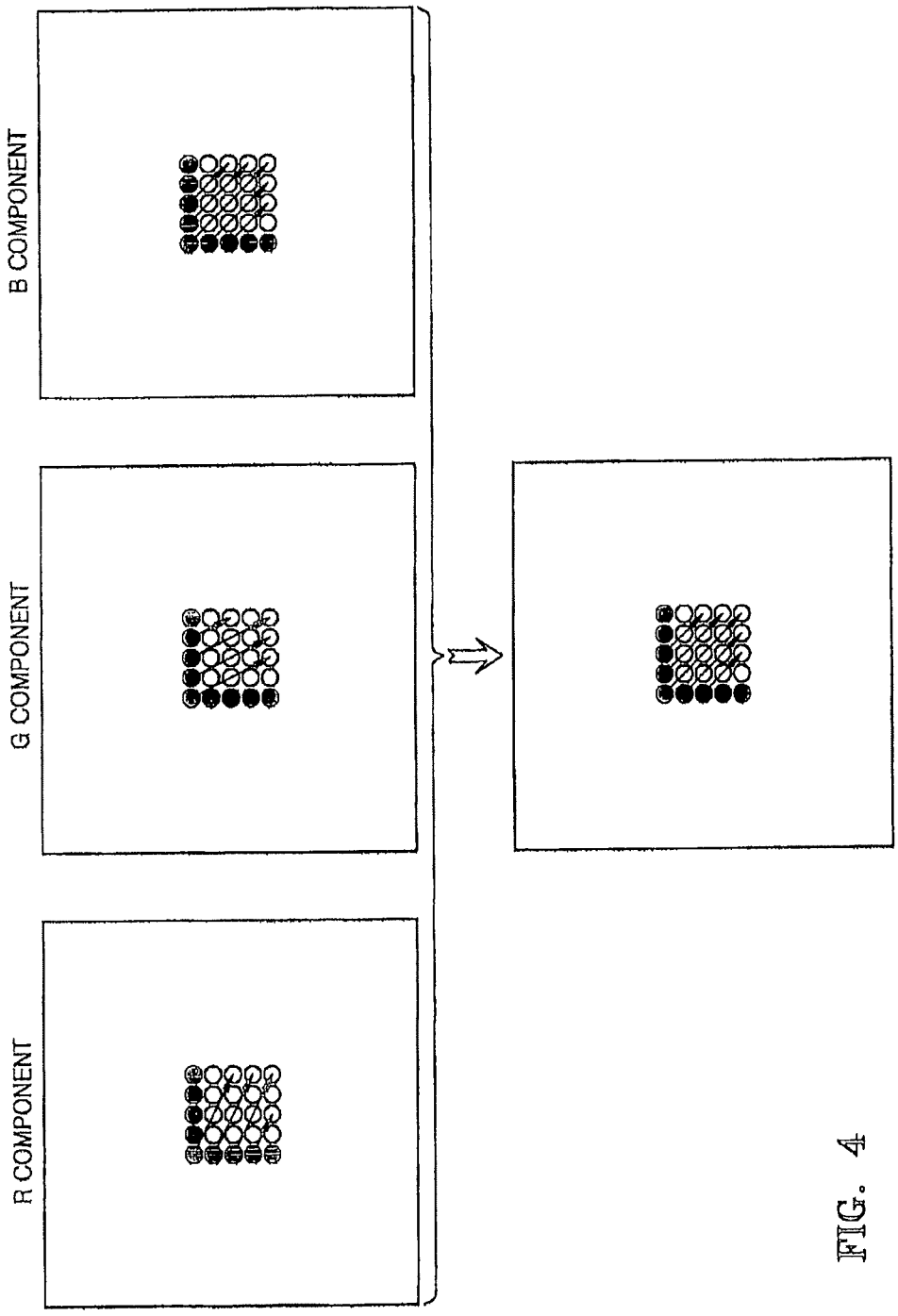
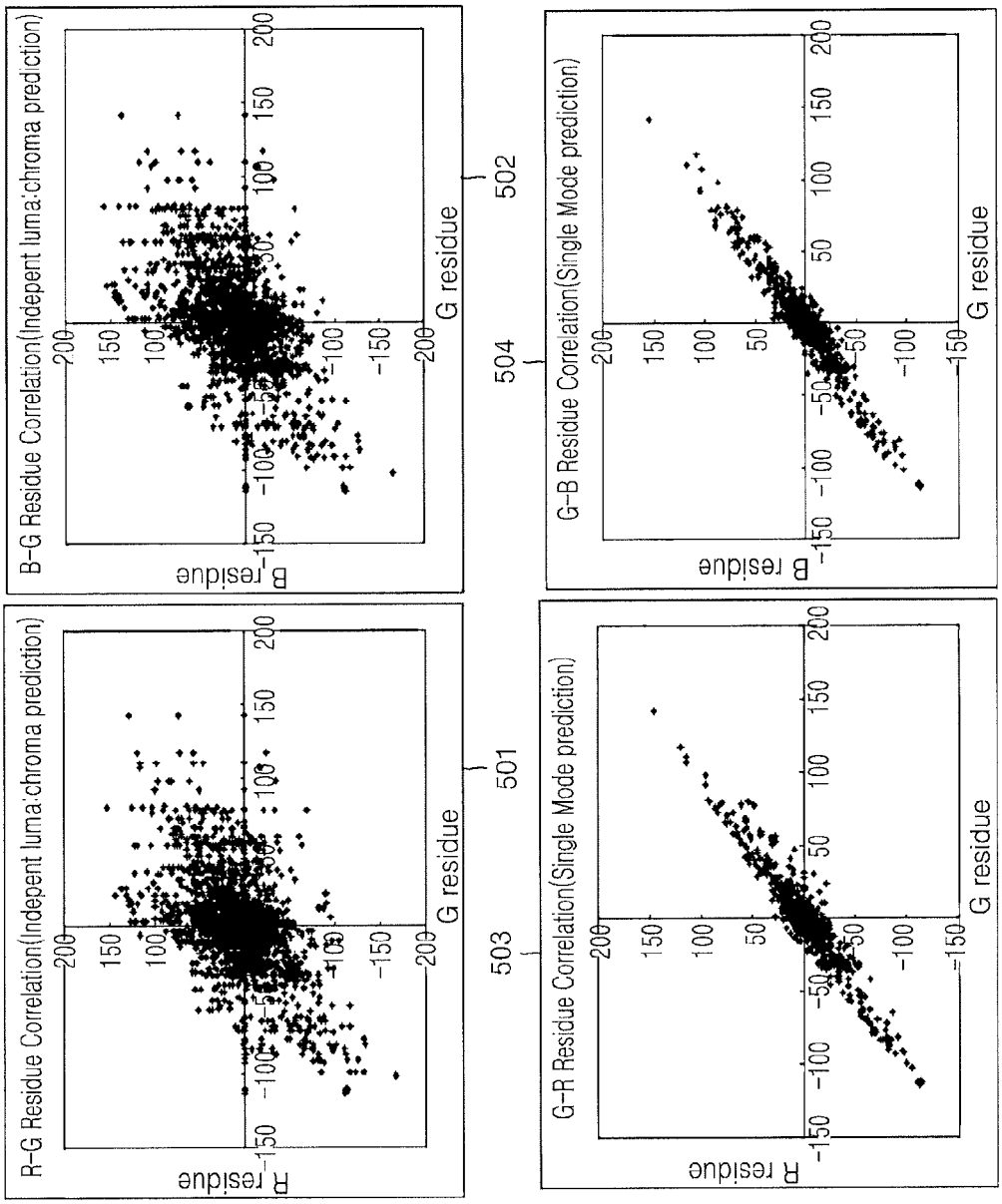


FIG. 4

FIG. 5


R-G Residue Correlation(Indepent luma:chroma prediction)
R residue
G residue
503
B-G Residue Correlation(Indepent luma:chroma prediction)
B residue
G residue
501
502
G-R Residue Correlation(Single Mode prediction)
R residue
G residue
504
G-B Residue Correlation(Single Mode prediction)
B residue
G residue

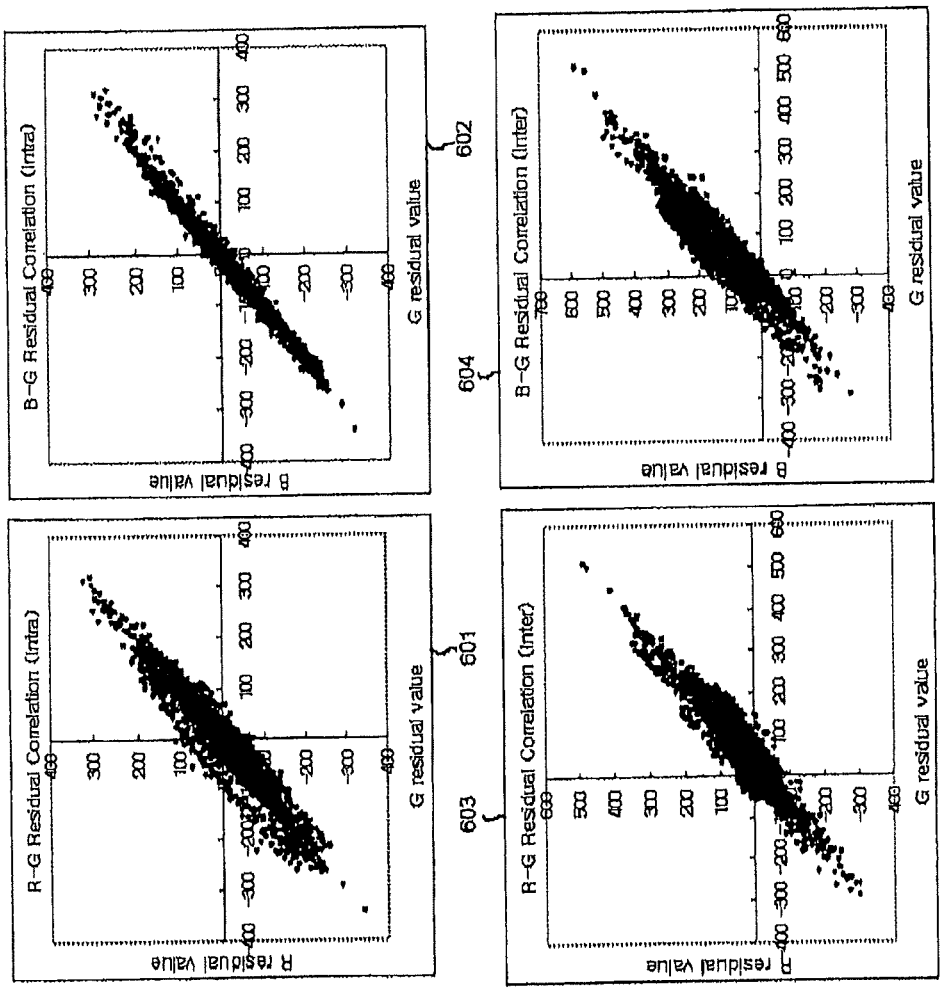

R-G Residual Correlation (Intra)
R residual value
G residual value
601
B-G Residual Correlation (Intra)
B residual value
G residual value
602
R-G Residual Correlation (Inter)
R residual value
G residual value
603
B-G Residual Correlation (Inter)
B residual value
G residual value
604

FIG. 6

FIG. 7

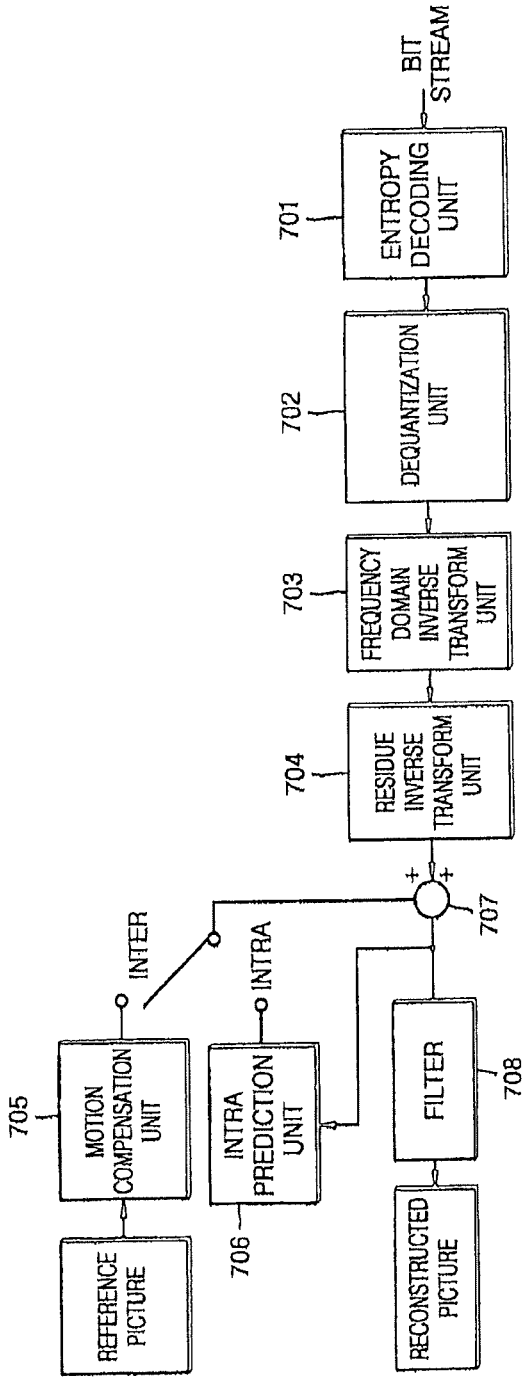

BIT STREAM
701
ENTROPY DECODING UNIT
702
DEQUANTIZATION UNIT
703
FREQUENCY DOMAIN INVERSE TRANSFORM UNIT
704
RESIDUE INVERSE TRANSFORM UNIT
707
+
+
INTER
INTRA
705
MOTION COMPENSATION UNIT
INTRA PREDICTION UNIT
706
FILTER
708
REFERENCE PICTURE
RECONSTRUCTED PICTURE

FIG. 8A

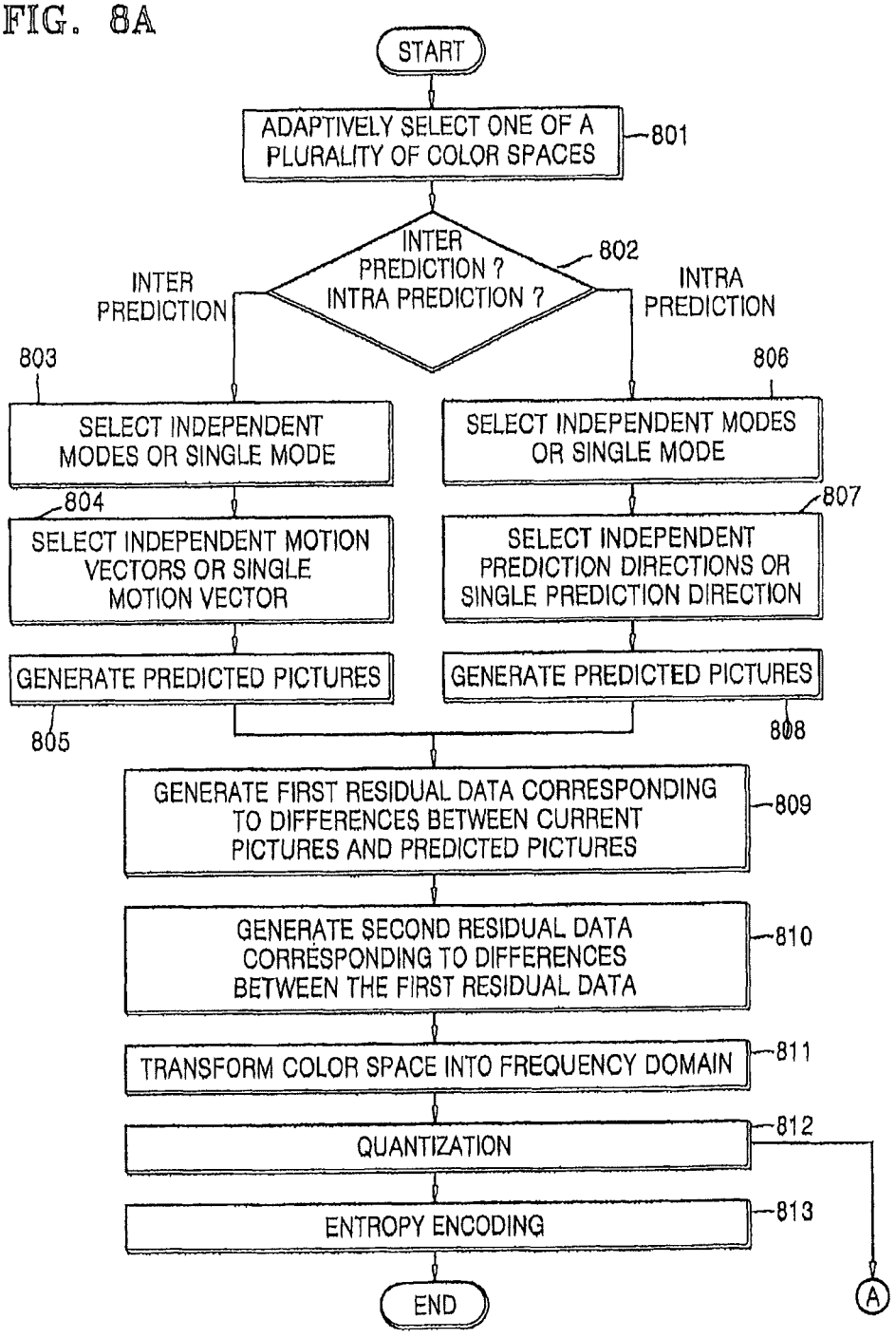

START
ADAPTIVELY SELECT ONE OF A PLURALITY OF COLOR SPACES
801
INTER PREDICTION ? INTRA PREDICTION ?
802
INTER PREDICTION
INTRA PREDICTION
803
806
SELECT INDEPENDENT MODES OR SINGLE MODE
SELECT INDEPENDENT MODES OR SINGLE MODE
804
807
SELECT INDEPENDENT MOTION VECTORS OR SINGLE MOTION VECTOR
SELECT INDEPENDENT PREDICTION DIRECTIONS OR SINGLE PREDICTION DIRECTION
GENERATE PREDICTED PICTURES
GENERATE PREDICTED PICTURES
805
808
GENERATE FIRST RESIDUAL DATA CORRESPONDING TO DIFFERENCES BETWEEN CURRENT PICTURES AND PREDICTED PICTURES
809
GENERATE SECOND RESIDUAL DATA CORRESPONDING TO DIFFERENCES BETWEEN THE FIRST RESIDUAL DATA
810
TRANSFORM COLOR SPACE INTO FREQUENCY DOMAIN
811
QUANTIZATION
812
ENTROPY ENCODING
813
END
A

FIG. 8B

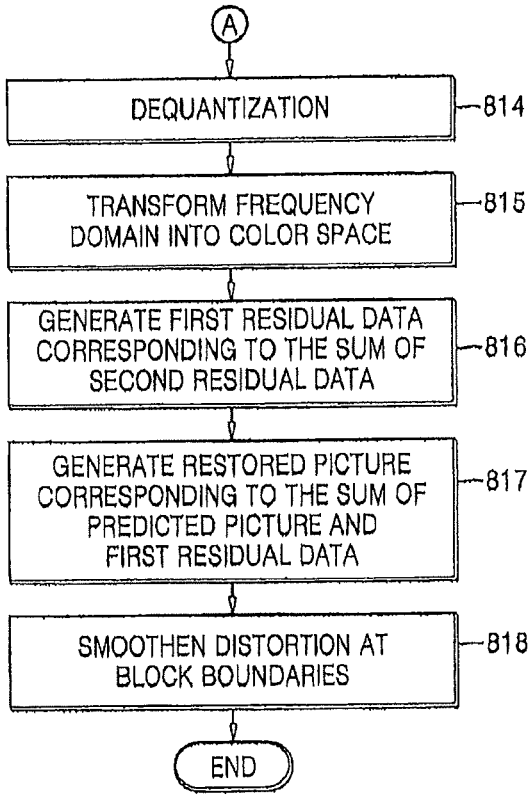

A
DEQUANTIZATION
814
TRANSFORM FREQUENCY DOMAIN INTO COLOR SPACE
815
GENERATE FIRST RESIDUAL DATA CORRESPONDING TO THE SUM OF SECOND RESIDUAL DATA
816
GENERATE RESTORED PICTURE CORRESPONDING TO THE SUM OF PREDICTED PICTURE AND FIRST RESIDUAL DATA
817
SMOOTHEN DISTORTION AT BLOCK BOUNDARIES
818
END

FIG. 9

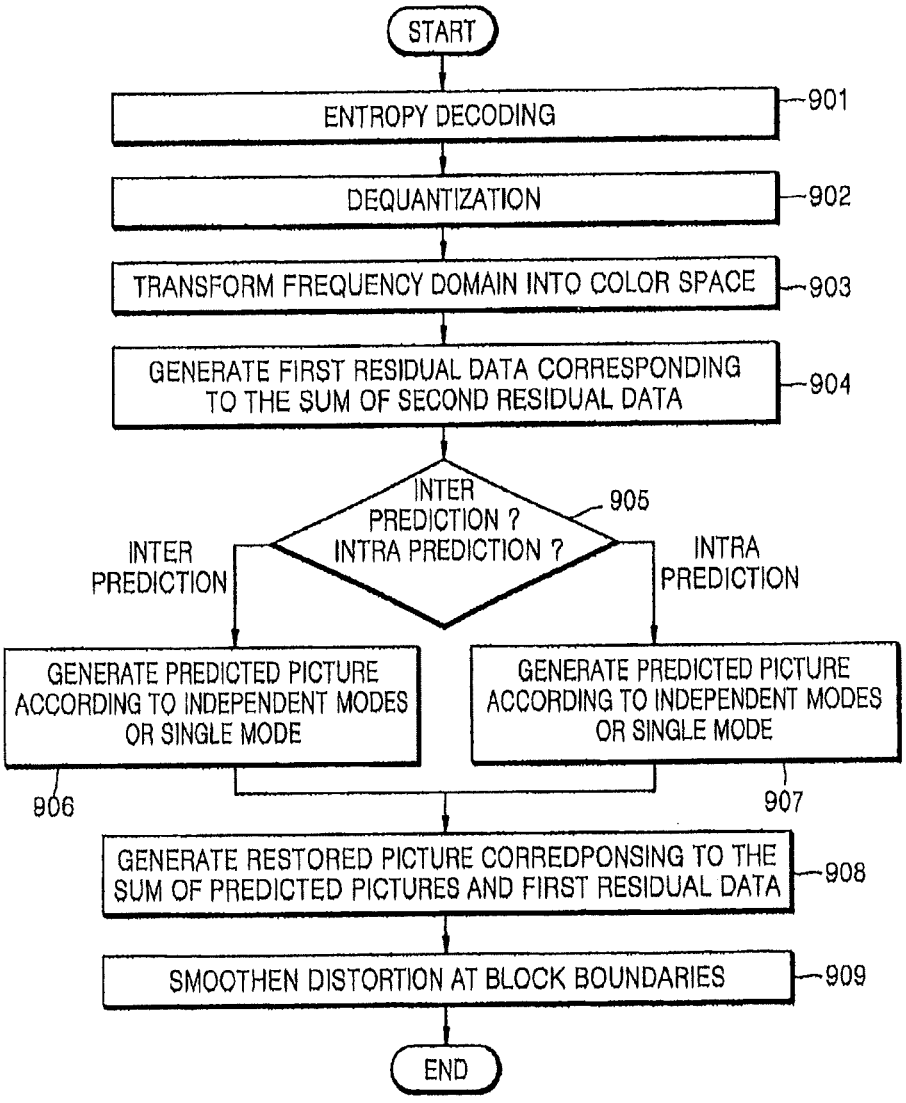

START
ENTROPY DECODING
901
DEQUANTIZATION
902
TRANSFORM FREQUENCY DOMAIN INTO COLOR SPACE
903
GENERATE FIRST RESIDUAL DATA CORRESPONDING TO THE SUM OF SECOND RESIDUAL DATA
904
INTER PREDICTION ? INTRA PREDICTION ?
905
INTER PREDICTION
INTRA PREDICTION
GENERATE PREDICTED PICTURE ACCORDING TO INDEPENDENT MODES OR SINGLE MODE
906
GENERATE PREDICTED PICTURE ACCORDING TO INDEPENDENT MODES OR SINGLE MODE
907
GENERATE RESTORED PICTURE CORREDPONSING TO THE SUM OF PREDICTED PICTURES AND FIRST RESIDUAL DATA
908
SMOOTHEN DISTORTION AT BLOCK BOUNDARIES
909
END

FIG. 10

1001

	RGB PSNR							
	20 Mbps				60 Mbps			
	RCT (FREXT)	RCT	IPP		RCT (FREXT)	RCT	IPP	
Analog TV	0.1	0.2	0.3		0.1	0.2	0.9	
CardToss	0.0	0.2	0.4		0.0	0.2	0.9	
Dinner	0.0	0.2	0.4		0.0	0.1	0.5	
tomatoes	0.0	0.1	0.1		-0.1	0.2	0.2	
Breeze	0.1	0.2	0.0		0.2	0.4	0.0	
Average	0.0	0.1	0.2		0.0	0.2	0.5	

1002

	Y PSNR							
	20 Mbps				60 Mbps			
	RCT (FREXT)	RCT	IPP		RCT (FREXT)	RCT	IPP	
Analog TV	0.2	0.2	0.7		0.2	0.4	1.5	
CardToss	0.2	0.3	0.8		0.2	0.4	1.5	
Dinner	0.2	0.4	0.7		0.2	0.3	1.5	
tomatoes	0.1	0.2	0.3		0.0	0.3	0.4	
Breeze	0.2	0.3	0.3		0.3	0.4	0.5	
Average	0.2	0.3	0.6		0.2	0.3	1.1	

FIG. 11

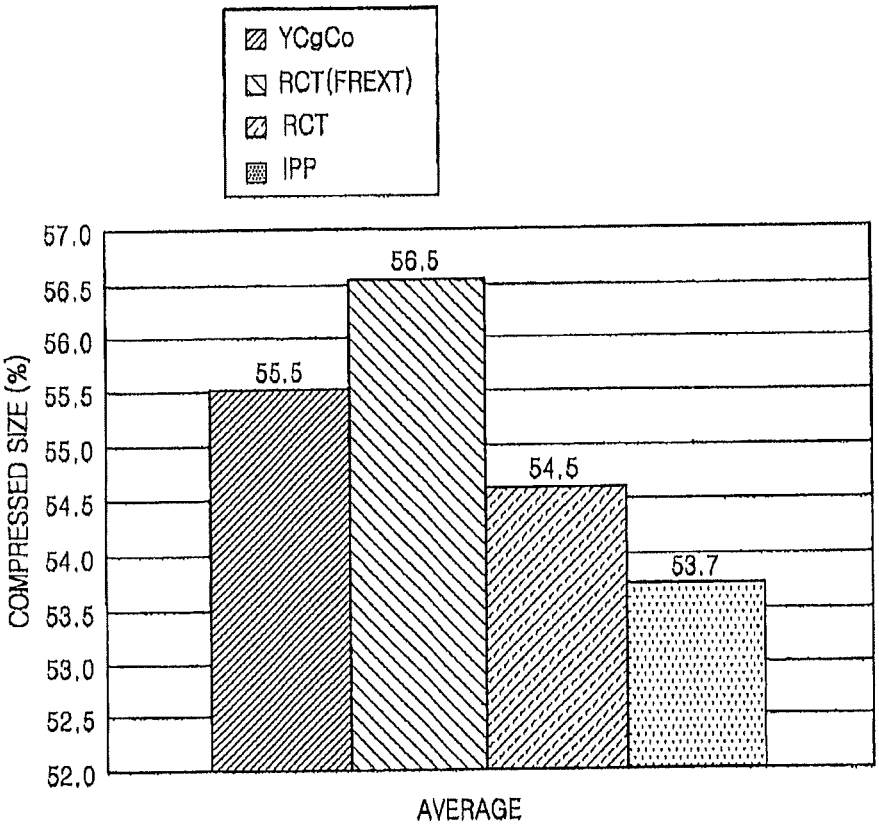

YCgCo
RCT(FREXT)
RCT
IPP
COMPRESSED SIZE (%)
57.0
56.5
56.0
55.5
55.0
54.5
54.0
53.5
53.0
52.5
52.0
55.5
56.5
54.5
53.7
AVERAGE

FIG. 12A

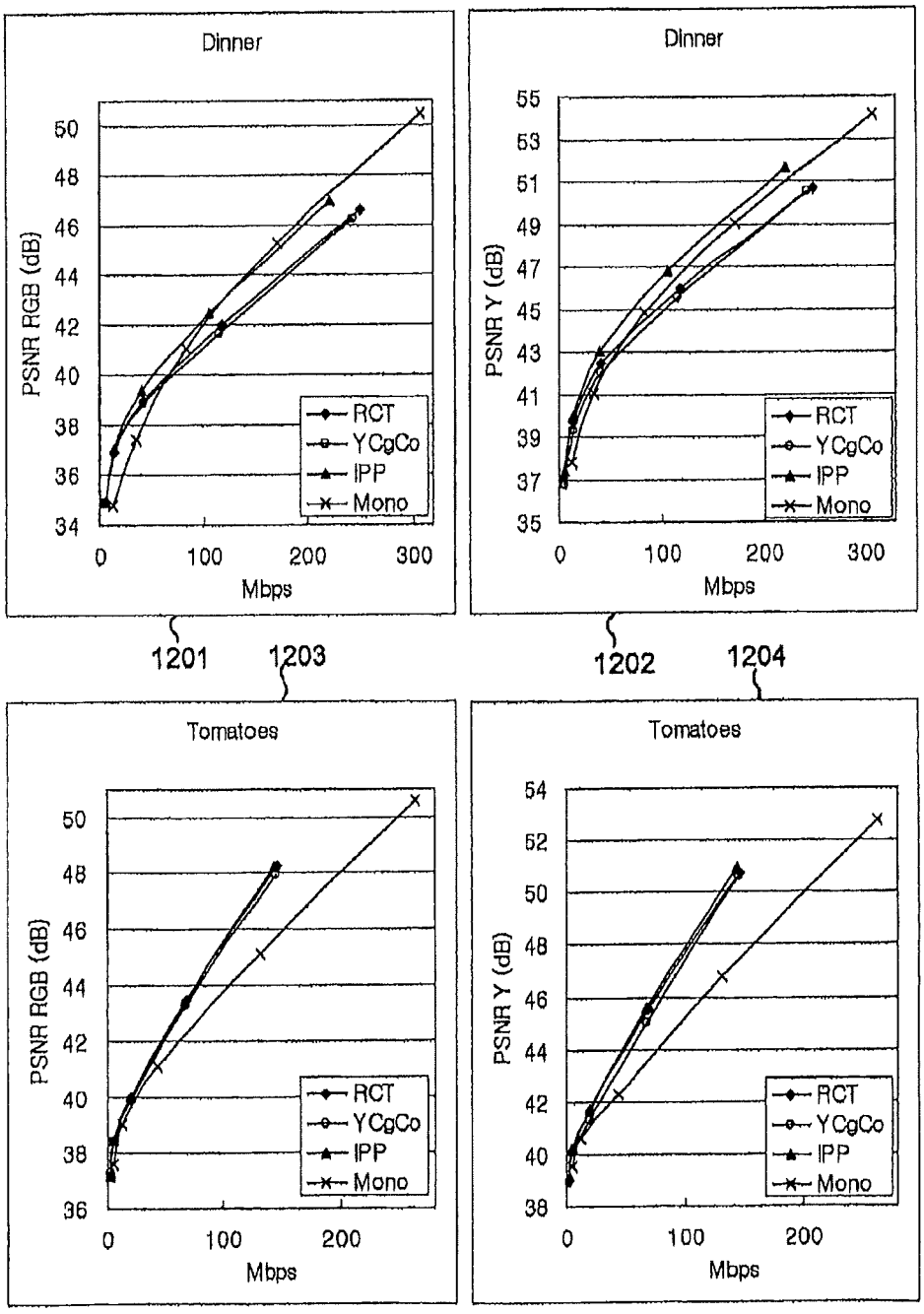
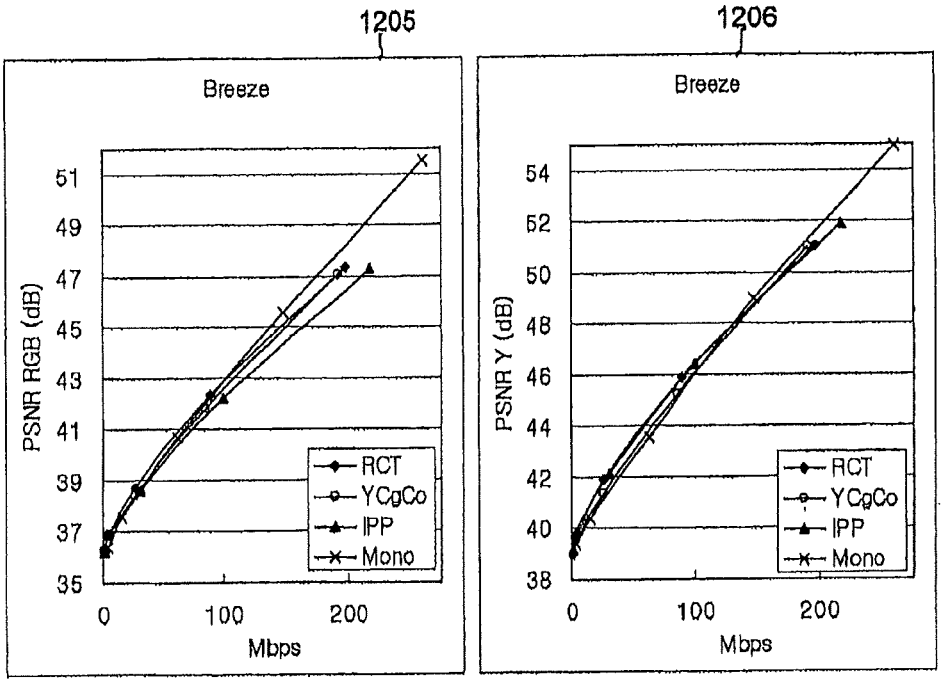

Dinner
PSNR RGB (dB)
50
48
46
44
42
40
38
36
34
0
100
200
300
Mbps
RCT
YCgCo
IPP
Mono
1201
Dinner
PSNR Y (dB)
55
53
51
49
47
45
43
41
39
37
35
0
100
200
300
Mbps
RCT
YCgCo
IPP
Mono
1202
1203
Tomatoes
PSNR RGB (dB)
50
48
46
44
42
40
38
36
0
100
200
Mbps
RCT
YCgCo
IPP
Mono
1204
Tomatoes
PSNR Y (dB)
54
52
50
48
46
44
42
40
38
0
100
200
Mbps
RCT
YCgCo
IPP
Mono

FIG. 12B


1205
1206
Breeze
Breeze
PSNR RGB (dB)
PSNR Y (dB)
51
49
47
45
43
41
39
37
35
54
52
50
48
46
44
42
40
38
0
100
200
Mbps
RCT
YCgCo
IPP
Mono

MOVING PICTURE CODING/DECODING METHOD AND APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation application of application U.S. patent application Ser. No. 14/597,627 filed in the United States on Jan. 15, 2015 now patented as U.S. Pat. No. 9,131,244, which is a continuation application of U.S. Ser. No. 11/405,420 filed in the United States on Apr. 18, 2006 now patented as U.S. Pat. No. 8,928,476, which claims the benefit of U.S. Provisional Patent Application No. 60/672,047, filed on Apr. 18, 2005, in the U.S. Trademark and Patent Office, the disclosures of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a moving picture coding/decoding method and apparatus, and more particularly, to a moving picture coding/decoding method and apparatus using the H.264/MPEG-4 AVC FRExt (Advanced Video Coding Fidelity Range Extensions) standard.

2. Description of Related Art

A new RGB coding technology referred to as "residual color transform" was developed during the development of the H.264/MPEG-4 AVC FRExt standard. This technology is for preventing image quality deterioration that occurs when a transform from a RGB color space to a YCbCr color space is performed. However, RGB coding technologies according to H.264/MPEG-4 AVC FRExt still do not ensure a sufficiently high coding efficiency to be applied to moving picture reproducing apparatuses.

Thus, there is a need for coding technologies according to H.264/MPEG-4 AVC FRExt that ensure a sufficiently high coding efficiency to be applied to moving picture reproducing apparatuses.

BRIEF SUMMARY

An aspect of the present invention provides a moving picture coding/decoding method and apparatus that can increase the coding efficiency of a moving picture using a RGB coding technology according to H.264/MPEG-4 AVC FRExt.

An aspect of the present invention also provides a computer readable recording medium having embodied thereon a computer program for the moving picture coding/decoding method.

According to an aspect of the present invention, there is provided a moving picture coding method comprising: (a) selecting a prediction mode to be commonly applied to all the color components constituting a color space; (b) generating first residual data corresponding to differences between a current picture and a predicted picture for each of the color components according to the prediction mode selected in operation (a); (c) generating second residual data corresponding to differences between the first residual data for each of the color components; and (d) coding the generated second residual data.

According another aspect of the present invention, there is provided a computer readable recording medium having embodied thereon a computer program for the above-described moving picture coding method.

According to another aspect of the present invention, there is provided a moving picture coding apparatus comprising: a selection unit selecting a prediction mode to be commonly applied to all the color components constituting a color space; a subtractor generating first residual data corresponding to differences between a current picture and a predicted picture for each of the color components according to the prediction mode selected by the selection unit; a transform unit generating second residual data corresponding to differences between the first residual data generated by the subtractor; and a coding unit coding the second residual data generated by the transform unit.

According to another aspect of the present invention, there is provided a moving picture coding method comprising: (a) selecting a color space from among a plurality of color spaces; (b) generating first residual data corresponding to differences between a current picture and a predicted picture for each of the color components constituting the selected color space; (c) generating second residual data corresponding to differences between the generated first residual data; and (d) coding the generated second residual data.

According to another aspect of the present invention, there is provided a computer readable recording medium having embodied thereon a computer program for the above-described moving picture coding method.

According to another aspect of the present invention, there is provided a moving picture coding apparatus comprising: a selection unit selecting a color space from among a plurality of color spaces; a subtractor generating first residual data corresponding to differences between a current picture and a predicted picture for each of the color components constituting the color space selected by the selection unit; a transform unit generating second residual data corresponding to differences between the first residual data generated by the subtractor; and a coding unit coding the second residual data generated by the transform unit.

According to another aspect of the present invention, there is provided a moving picture coding method comprising: (a) selecting a color space from among a plurality of color spaces; (b) selecting a prediction mode to be commonly applied to all the color components constituting the selected color space; (b) generating first residual data corresponding to differences between a current picture and a predicted picture for each of the color components constituting the selected color space according to the selected prediction mode; (c) generating second residual data corresponding to differences between the generated first residual data; and (d) coding the generated second residual data.

According to another aspect of the present invention, there is provided a computer readable recording medium having embodied thereon a computer program for the above-described moving picture coding method.

According to another aspect of the present invention, there is provided a moving picture coding apparatus comprising: a first selection unit selecting a color space from among a plurality of color spaces; a second selection unit selecting a prediction mode to be commonly applied to all the color components constituting the color space selected by the first selection unit; a subtractor generating first residual data corresponding to differences between a current picture and a predicted picture for each of the color components according to the prediction mode selected by the second selection unit; a transform unit generating second residual data corresponding to differences between the first residual data generated by the subtractor; and a coding unit coding the second residual data generated by the transform unit.

According to another aspect of the present invention, there is provided a moving picture coding method comprising: (a) selecting first prediction modes to be independently applied

to color components constituting a color space or a second prediction mode to be commonly applied to all the color components of the color space; and (b) generating first residual data corresponding to differences between a current picture and a predicted picture for each of the color components according to the first prediction modes or the second prediction mode selected in operation (a).

According to another aspect of the present invention, there is provided a computer readable recording medium having embodied thereon a computer program for the above-described moving picture coding method.

According to another aspect of the present invention, there is provided a moving picture coding apparatus comprising: a selection unit selecting first prediction modes to be independently applied to color components constituting a color space or a second prediction mode to be commonly applied to all the color components of the color space; and a subtractor generating first residual data corresponding to differences between a current picture and a predicted picture for each of the color components according to the first prediction modes or the second prediction mode selected by the selection unit.

According to another aspect of the present invention, there is provided a moving picture decoding method comprising: (a) generating second residual data corresponding to differences between first residual data by decoding a bitstream; (b) generating the first residual data corresponding to the sum of the generated second residual data in a color space; (c) generating a prediction picture for each color component constituting the color space according to a prediction mode that is commonly applied to all the color components; and (d) generating a reconstructed picture corresponding to the sum of the generated first residual data and the generated predicted pictures.

According to another aspect of the present invention, there is provided a computer readable recording medium having embodied thereon a computer program for the above-described moving picture decoding method.

According to another aspect of the present invention, there is provided a moving picture decoding apparatus comprising: a decoding unit generating second residual data corresponding to differences between first residual data by decoding a bitstream; an inverse transform unit generating first residual data corresponding to the sum of the generated second residual data in a color space; a prediction unit generating a prediction picture for each color component constituting the color space according to a prediction mode that is commonly applied to all the color components; and an adder generating a reconstructed picture corresponding to the sum of the first residual data generated by the inverse transform unit and the predicted pictures generated by the prediction unit.

According to another aspect of the present invention, there is provided a moving picture decoding method comprising: (a) generating second residual data corresponding to differences between first residual data by decoding a bitstream; (b) generating the first residual data corresponding to the sum of the generated second residual data in a color space selected from among a plurality of color spaces; (c) generating a reconstructed picture corresponding to the sum of the generated first residual data and predicted pictures.

According to another aspect of the present invention, there is provided a computer readable recording medium having embodied thereon a computer program for the above-described moving picture decoding method.

According to another aspect of the present invention, there is provided a moving picture decoding apparatus comprising: a decoding unit generating second residual data corresponding to differences between first residual data by decoding a bitstream; an inverse transform unit generating the first residual data corresponding to the sum of the generated second residual data in a color space selected from among a plurality of color spaces; and an adder generating a reconstructed picture corresponding to the sum of the first residual data generated by the inverse transform unit and predicted pictures.

According to another aspect of the present invention, there is provided a moving picture decoding method comprising: (a) generating second residual data corresponding to differences between first residual data by decoding a bitstream; (b) generating the first residual data corresponding to the sum of the generated second residual data in a color space selected from among a plurality of color spaces; (c) generating a predicted picture for each color component of the color space according to a prediction mode that is commonly applied to all the color components; and (d) generating a reconstructed picture corresponding to the sum of the generated first residual data and the generated predicted pictures.

According to another aspect of the present invention, there is provided a computer readable recording medium having embodied thereon a computer program for the above-described moving picture decoding method.

According to another aspect of the present invention, there is provided a moving picture decoding apparatus comprising: a decoding unit generating second residual data corresponding to differences between first residual data by decoding a bitstream; an inverse transform unit generating the first residual data corresponding to the sum of the generated second residual data in a color space selected from among a plurality of color spaces; a prediction unit generating a predicted picture for each of the color components constituting the color space according to a prediction mode that is commonly applied to all the color components; and an adder generating a reconstructed picture corresponding to the sum of the first residual data generated by the inverse transform unit and the predicted pictures generated by the prediction unit.

According to another aspect of the present invention, there is provided a moving picture decoding method comprising: (a) generating a prediction picture for each color component constituting the color space according to first prediction modes that are independently applied to the color components constituting the color space or a second prediction mode that is commonly applied to all the color components; and (b) generating a reconstructed picture based on the generated predicted pictures.

According to another aspect of the present invention, there is provided a computer readable recording medium having embodied thereon a computer program for the above-described moving picture decoding method.

According to another aspect of the present invention, there is provided a moving picture decoding apparatus comprising: a prediction unit generating a prediction picture for each color component constituting the color space according to first prediction modes that are independently applied to the color components constituting the color space or a second prediction mode that is commonly applied to all the color components constituting the color space; and an adder generating a reconstructed picture based on the predicted pictures generated by the prediction unit.

According to another aspect of the present invention, there is provided an image decoding apparatus comprising: a processor which obtains information about a color representation from a bitstream, obtains a residue, which corresponds to a difference between a current image and a predicted image of the current image, from the bitstream, and reconstructs the

current image by using the residue and the predicted image, based on the information about the color representation, wherein the processor is configured to obtain a prediction direction of a chroma component from among a plurality of prediction modes associated with a prediction mode of a luma component, wherein the plurality of prediction modes include a first mode in which the prediction direction of the chroma component is identical to the prediction direction of the luma component and a second mode in which the prediction direction of the chroma component is different from the prediction direction of the luma component, and to obtain the predicted image based on the prediction direction of the luma component and the prediction direction of the chroma component.

According to another aspect of the present invention, there is provided an apparatus, wherein the information about the color representation indicates a color space into which color components are represented.

Additional and/or other aspects and advantages of the present invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and/or other aspects and advantages of the present invention will become apparent and more readily appreciated from the following detailed description, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a block diagram of a moving picture coding apparatus according to an embodiment of the present invention;

FIG. **2** illustrates the selection of a size of blocks in the moving picture coding apparatus of FIG. **1**;

FIG. **3** illustrates the selection of a motion vector in the moving picture coding apparatus of FIG. **1**;

FIG. **4** illustrates the selection of a prediction direction in the moving picture coding apparatus in FIG. **1**;

FIG. **5** illustrates changes in correlation between residual data when a single prediction mode is applied to different color components in an embodiment according to the present invention;

FIG. **6** illustrates the correlation between color components when a single prediction mode is applied to all the color components in an embodiment of the present invention.

FIG. **7** is a block diagram of a moving picture decoding apparatus according to an embodiment of the present invention;

FIGS. **8**A and **8**B are flowcharts of a moving picture coding method according to an embodiment of the present invention;

FIG. **9** is a flowchart of a moving picture decoding method according to an embodiment of the present invention;

FIG. **10** is the results of a simulation test according to embodiments of the present invention.

FIG. **11** is a graph comparatively showing the coding efficiencies in a lossless mode in embodiments according to the present invention; and

FIGS. **12**A and **12**B are rate distortion (RD) curves obtained through a simulation of embodiments of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.

FIG. **1** is a block diagram of a moving picture coding apparatus according to an embodiment of the present invention.

Referring to FIG. **1**, a moving picture coding apparatus according to an embodiment of the present invention includes a color space selection unit **101**, an inter prediction mode selection unit **102**, a motion estimation unit **103**, a motion compensation unit **104**, an intra prediction mode selection unit **105**, an intra prediction unit **106**, a subtractor **107**, a residue transform unit **108**, a frequency domain transform unit **109**, a quantization unit **110**, an entropy coding unit **111**, an dequantization unit **112**, a frequency domain inverse transform unit **113**, a residue inverse transform unit **114**, an adder **115**, and a filter **116**.

The color space selection unit **101** adaptively selects a color space from among a plurality of color spaces based on the characteristics of a current picture. Non-limiting examples of color spaces include a YCgCo color space and a RGB color space. In the YCgCo color space, Y indicates a luma component, Co indicates a chroma orange component, and Cg indicates a chroma green component. In the RGB color space, R indicates red color component, G indicates a green color component, and B indicates a blue color component.

A scheme of coding a current picture will be referred to hereafter as "residual color transform" or (RCT) in the YCgCo color space and as "inter-plane prediction" or (IPP) in the RGB color space.

The RGB color space includes an R component, a G component, and a B component which can be perceived by humans. Accordingly, when the color space selection unit **101** selects another color space, for example, the YCgCo color space, not the RGB color space, after coding has been performed in the YCgCo color space, a transform from the YCgCo color space to the RGB color space should be performed.

According to the results of numerous experiments performed using sets of high quality images, such as high definition (HD) moving pictures, film scan images, Thompson Viper sequences, etc., there is no panacea for images having various characteristics and bit rates. Some images contain serious film grain noise in a color component, other images contain thermal noise, and other images have saturated color characteristics. RCT is efficient in a certain case, and IPP is efficient in another case. Therefore, in the present embodiment, one of RCT and IPP is adaptively used according to image characteristics. A moving picture decoding apparatus may be informed as to which of RCT and IPP is used in the moving picture coding apparatus by a single bit flag according to H.264/MPEG-4 AVC FRExt.

In a high bit rate environment, the coding efficiency of moving pictures is higher in RCT than in IPP. However, in RCT, due to the transform between different color spaces, the image quality deteriorates. Especially, when many noise components exist in a current picture or when the configuration of a current picture is complex, such image quality deterioration is serious. The color space selection unit **101** selects the RGB color space when many noise components exist in a current picture or when the configuration of a current picture is complex, or the YCgCo color space when almost no noise components exist in a current picture or when the configuration of a current picture is simple. In other words, the color

space selection unit **101** adaptively selects a color space based on the characteristics of the moving picture, such as bit rate, coded sequences, etc.

The inter prediction mode selection unit **102** selects inter prediction modes to be independently applied to the color components constituting the color space selected by the color selection unit **101** or a single inter prediction mode to be commonly applied to all the color components constituting the color space selected by the color space selection unit **101**. In general, when all color components have different motion vectors in an inter prediction mode, residual data of the all color components have different characteristics, and thus there is almost no correlation between the residual data of the different color components. Thus, in the present embodiment, the use of a single prediction mode, i.e., a single block size, a single motion vector, etc., for all the color components is suggested to increase the correlation between the residual data of the different color components. The use of a single prediction mode provides more natural images than when RGB components have similar texture characteristics. In addition, a moving picture decoding apparatus may be informed as to which of a single mode and a conventional independent mode is used in the moving picture coding apparatus by a single bit flag according to H.264/MPEG-4 AVC FRExt.

A case where the inter prediction mode selection unit **102** selects a single mode will be described in detail. The inter prediction mode selection unit **102** selects a size of blocks to be commonly applied to all the color components constituting the color space selected by the color space selection unit **101**. The sizes of blocks constituting the current picture can be 16×16, 16×8, 8×1, 8×8, 8×4, 4×8, 4×4, etc. In general, a 16×16 block is referred to as "macroblock", and blocks obtained by dividing a macroblock to various sizes are referred as to "subblocks". Moving picture coding and decoding are performed in such block units. A portion of a moving picture that requires more accurate coding and decoding is coded and decoded in smaller block units.

In particular, the inter prediction mode selection unit **102** selects a size of blocks to be commonly applied to all color components. For example, the inter prediction mode selection unit **102** selects a size of blocks to be commonly applied to the Y component, the Co component, and the Cg component from among the sizes of blocks of the Y component, the sizes of blocks of the Cg component, and the sizes of blocks of the Cg component. Alternatively, the inter prediction mode selection unit **102** selects a size of blocks to be commonly applied to the R component, the G component, and the B component from among the sizes of blocks of the R component, the sizes of blocks of the G component, and the sizes of the blocks of the B component.

FIG. **2** illustrates the selection of a size of blocks in the moving picture coding apparatus of FIG. **1**.

Referring to FIGS. **1** and **2**, the inter prediction mode selection unit **102** selects a size of blocks that is optimal to the macroblocks of all the color components and are commonly applied to all the color components from among the sizes of blocks constituting a macroblock of the R component, the sizes of blocks constituting a macroblock of the G component, and the sizes of blocks constituting a macroblock of the B component. This selection can apply to the YCgCo color space.

Next, the inter prediction mode selection unit **102** selects a single motion vector to be commonly applied to all the color components constituting the color space from among motion vectors of all the color components in units of blocks corresponding to the selected size of blocks. In particular, the inter prediction mode selection unit **102** selects a single motion vector to be commonly applied to all the color components from among the motion vectors of the color components calculated by the motion estimation unit **103**. For example, the inter prediction mode selection unit **102** selects a single motion vector to be commonly applied to all the Y component, Co component, and Cg component from among the motion vector of the Y component, the motion vector of the Co component, and the motion vector of the Cg component that are calculated by the motion estimation unit **103**. Alternatively, the inter prediction mode selection unit **102** selects a single motion vector to be commonly applied to all the R component, G component, and B component from among a motion vector of the R component, a motion vector of the G component, and a motion vector of the B component that are calculated by the motion estimation unit **103**.

FIG. **3** illustrates the selection of a motion vector in the moving picture coding apparatus of FIG. **1**.

Referring to FIGS. **1** and **3**, the inter prediction mode selection unit **102** selects a single motion vector that is optimal to the blocks of all the color components from among the motion vector for a block of the R component, the motion vector for a block of the G component, and the motion vector for a block of the B component. This selection can apply to the YCgCo color space.

The motion estimation unit **103** estimates motion in the current picture for each color component based on a reference picture according to an inter prediction mode selected by the inter prediction mode selection unit **102**. In particular, the motion estimation unit **103** selects motion vectors to be independently applied to the color components constituting the color space in units of blocks that are independent for the color components or selects a motion vector to be commonly applied to the color components constituting the color spaces in units of blocks that are common to all the color components according to the inter prediction mode selected by the inter prediction mode selection unit **102**.

A case where the motion estimation unit **103** estimates motion according to a single mode will be described. The motion estimation unit **103** calculates a motion vector corresponding to the displacement in the current picture with respect to the reference picture in units of blocks corresponding to the size of blocks selected by the inter prediction mode selection unit **102**. In the present embodiment, the current picture refers to an object picture on which coding and decoding are performed. The reference picture indicates a picture referred to when coding or decoding the current picture. In general, a picture preceding the current picture is used as a reference picture. However, a picture following the current picture also can be sued as a reference picture. Alternatively, a plurality of reference pictures can be used.

For example, the motion estimation unit **103** calculates a motion vector of the Y component, a motion vector of the Co component, and a motion vector of the Cg component by estimating motion in the current picture for each of the Y component, Co component, and Cg component based on the reference picture according to the inter prediction mode selected by the inter prediction mode selection unit **102**. Alternatively, the motion estimation unit **103** calculates a motion vector of the R component, a motion vector of the G component, and a motion vector of the B component by estimating motion in the current picture for each of the R component, G component, and B component based on the reference picture according to the inter prediction mode selected by the prediction mode selection unit **102**.

The motion compensation unit **104** compensates for the motion between the current picture and the reference picture

according to the inter prediction mode selected by the inter prediction mode selection unit **102**. In particular, the motion compensation unit **104** generates a predicted picture in the current picture from the reference picture in units of blocks corresponding to the size of blocks selected by the inter prediction mode selection unit **102** using the motion vector selected by the inter prediction mode selection unit **102**. The inter prediction performed by the motion estimation unit **103** and the motion compensation unit **104** is for removing temporal redundancy between the current picture and the reference picture.

For example, the motion compensation unit **104** generates a predicted picture for the Y component, a predicted picture for the Co component, and a predicted picture for the Cg component by compensating for the motion between the current picture and the reference picture according to the inter prediction mode selected by the inter prediction mode selection unit **102**. Alternatively, the motion compensation unit **104** generates a predicted picture for the R component, a predicted picture for the G component, and a predicted picture for the B component by compensating for the motion between the current picture and the reference picture according to the inter prediction mode selected by the inter prediction mode selection unit **102**.

The intra prediction mode selection unit **105** selects intra prediction modes to be independently applied to the color components constituting the color space selected by the color space selection unit **101** or a single intra prediction mode to be commonly applied to all the color components constituting the color space selected by the color space selection unit **101**. According to MPEG-4 AVC/H.264 video coding schemes, there are 9 intra prediction modes in units of 4×4 blocks and 4 intra prediction modes in units of 16×16 blocks for a luma component, and 4 intra prediction modes in units of 8×8 blocks for a chroma component. In general, since prediction modes for the luma component and the chroma component are different, the correlation between the color components is low, which is disadvantageous in RCT, IPP, or other similar transforms. The coding efficiency for moving pictures can be increased by applying a single intra prediction mode to all the color components. Therefore, in the present embodiment, an intra prediction mode in units of 4×4, 8×8, or 16×16 blocks for the luma component is applied to the chroma component.

The intra prediction mode selection unit **105** selects prediction directions to be independently applied to the color components constituting the color space, or selects a prediction direction to be commonly applied to all the color components constituting the color space from among prediction directions for the color components constituting the color space according to the intra prediction mode selected by the intra prediction mode selection unit **105**. A case where the intra prediction mode selection unit **105** selects a single mode will be described in detail. The intra prediction mode selection unit **105** selects a size of blocks to be commonly applied to all the color components constituting the color space selected by the color space selection unit **101**. The sizes of blocks constituting the current picture can be 16×16, 8×8, 4×4, etc. The selection of a size of blocks for intra prediction is performed in the same manner as for the inter prediction illustrated in FIG. **2**.

Next, the intra prediction mode selection unit **105** selects a single prediction direction to be commonly applied to all the color components constituting the color space in units of blocks corresponding to the size of blocks selected above from among prediction directions of the color components constituting the color space. For example, the intra prediction mode selection unit **105** selects a single prediction direction to be commonly applied to the Y component, Co component, and Cg component from among a prediction direction of the Y component, a prediction direction of the Co component, and a prediction direction of the Cg component. Alternatively, the intra prediction mode selection unit **105** selects a single prediction direction to be commonly applied to the R component, G component, and B component from among a prediction direction of the R component, a prediction direction of the G component, and a prediction direction of the B component.

FIG. **4** illustrates the selection of a prediction direction in the moving picture coding apparatus of FIG. **1**.

Referring to FIGS. **1** and **4**, the intra prediction mode selection unit **105** selects a single prediction direction that is optimal to the blocks of all the color components and is to be commonly applied to all the color components from among a prediction direction for a block in the R component, a prediction direction for a block in the G component, and a prediction direction for a block in the B component. This selection can apply to the YCgCo color space.

The intra prediction unit **106** estimates blocks constituting the current picture from adjacent pixels in a picture reconstructed by an adder **115**, according to the intra prediction mode selected by the intra prediction mode selection unit **105**, and generates a predicted picture constituted by the predicted blocks. In particular, the intra prediction unit **106** estimates blocks constituting the current picture from adjacent pixels indicated by the prediction directions, which are independently applied to the color components of the color space, in units of blocks that are independent for the color components, and generates a predicted picture constituted by the predicted blocks. Alternatively, the intra prediction unit **106** estimates blocks constituting the current picture from adjacent pixels indicated by the prediction direction, which is commonly applied to all the color components of the color space, in units of blocks that are common to all the color components, and generates a predicted picture constituted by the prediction direction. The intra prediction performed by the intra prediction unit **106** is for removing spatial redundancy in the current picture.

For example, the intra prediction unit **106** predicts blocks constituting the current picture from adjacent pixels for each of the Y component, Co component, and Cg component indicated by the prediction direction selected by the intra prediction mode selection unit **105** and generates a predicted picture for the Y component, a predicted picture for the Co component, and a predicted picture for the Cg component. Alternatively, the intra prediction unit **106** predicts blocks constituting the current picture from adjacent pixels for each of the R component, G component, and B component indicated by the prediction direction selected by the intra prediction mode selection unit **105** and generates a predicted picture for the R component, a predicted picture for the G component, and a predicted picture for the B component.

The subtractor **107** generates first residual data corresponding to differences between the current picture and the predicted picture for each of the color components generated by the motion compensation unit **104** or by the intra prediction unit **106**. For example, the subtractor **107** generates the first residual data for the Y component, the first residual data for the Co component, and the first residual data for the Cg component by calculating differences between the current picture and the predicted picture for each of the Y component, Co component, and Cg component that are generated by the motion compensation unit **104** or by the intra prediction unit **106**. Alternatively, the subtractor **107** generates the first residual data for the R component, the first residual data for

the G component, and the first residual data for the B component by calculating differences between the current picture and the predicted picture for each of the R component, G component, and B component that are generated by the motion compensation unit **104** or by the intra prediction unit **106**.

FIG. **5** illustrates changes in correlation between residual data when a single prediction mode is applied to different color components in an embodiment according to the present invention.

Referring to FIG. **5**, plots **501** and **502** illustrate the correlation between residual data obtained by applying independent prediction modes to the color components. In particular, plot **501** illustrates the correlation between residual data for the R component and the G component, and plot **502** illustrates the correlation between residual data for the B component and the G component. Meanwhile, plots **503** and **504** illustrate the correlation between residual data obtained by applying a signal prediction mode to all the color components. In particular, plot **503** illustrates the correlation between residual data for the R component and G component, and plot **504** illustrates the correlation between residual data for the B component and the G component. As is apparent from the plots **501** through **504** in FIG. **5**, the correlation between residual data for color components is higher when a single prediction mode is applied to all the color components than when independent prediction modes are applied to the all the color components.

The residue transform unit **108** of FIG. **1** generates second residual data corresponding to differences between the first residual data generated by the subtractor **107** of FIG. **1**. In the present embodiment, to increase the coding efficiency for moving pictures, redundancy between the color components that remains after the prediction or intra prediction is utilized. The inter prediction utilizes temporal redundancy, and the intra prediction utilizes spatial redundancy. However, redundancy between the color components still remains after the inter prediction or intra prediction.

FIG. **6** illustrates the correlation between color components when a single prediction mode is applied to all the color components in an embodiment of the present invention.

Referring to FIGS. **1** and **6**, plot **601** illustrates the correlation between the R component and the G component after intra prediction. Plot **602** illustrates the correlation between the B component and the G component after intra prediction. Plot **603** illustrates the correlation between the R component and the G component after inter prediction, and plot **604** illustrates the correlation between the B component and the G component after inter prediction. As is apparent from the plots **601** through **604** in FIG. **6**, there still remains a strong correlation between the residual data for the color components after the inter prediction or intra prediction.

In other words, the residue transform unit **108** generates second residual data corresponding to differences between the first residual data for each of the Y component, the Co component, and the Cg component in the YCgCo color space using Equation Set (1) below. In particular, Y=(R+2G+B)>>2, Co=(R−B)>>1, and Cg=(−R+2G−B)>>2.

$$\Delta^2 B=\Delta R-\Delta B$$

$$t=\Delta B+(\Delta^2 B>>1)$$

$$\Delta^2 R=\Delta G-t$$

$$\Delta^2 G=t+(\Delta^2 R>>1) \quad \text{Equation Set (1)}$$

Here, ΔX denotes first residual data, Δ^2X denotes second residual data, the notation ">>" denotes right shift operation, which approximates a division by 2, and variable t is used to the purpose of temporary calculation.

Alternatively, the residue transform unit **108** generates second residual data corresponding to differences between the first residual data for each of the R component, the G component, and the B component in the RGB color space using Equation Set (2) below.

$$\Delta^2 G=\Delta G'$$

$$\Delta^2 R=\Delta R-\Delta G'$$

$$\Delta^2 B=\Delta B-\Delta G' \quad \text{Equation Set (2)}$$

Here, ΔX denotes first residual data, Δ^2X denotes second residual data, and ΔX' denotes reconstructed first residual data. Equation (2) is effective when the G component has a large amount of picture information. The second residual data can be calculated using the R component or B component as a dominant component.

The frequency domain transform unit **109** transforms the second residual data in the color space generated by the residue transform unit **108** into second residual data in a frequency domain. According to H.264/MPEG-4 AVC, discrete hadamard transform (DHT), discrete cosine transform (DCT)-based integer transform, etc., are used as schemes for transform from the color space to the frequency domain.

The quantization unit **110** quantizes the frequency component values transformed by the frequency domain transform unit **109**. In particular, the quantization unit **110** divides the frequency component values transformed by the frequency domain transform unit **109** by a quantization parameter and approximates the divided results to integer values.

The entropy coding unit **111** generates a bitstream by entropy-coding the quantized values obtained by the quantization unit **110** and outputs the bitstream. According to H.264/MPEG-4 AVC, context-adaptive variable length coding (CAVLC), context-adaptive binary arithmetic coding (CABAC), etc., are used as entropy coding schemes.

The dequantization unit **112** dequantizes the quantized values obtained by the quantization unit **110**. In particular, the dequantization unit **112** reconstructs the frequency domain values by multiplying the integer values approximated by the quantization unit **110** by the quantization parameter.

The frequency domain inverse transform unit **113** reconstructs the second residual data by transforming the frequency component values in the frequency domain reconstructed by the dequantization unit **112** into data in the color space.

The residue inverse transform unit **114** generates first residual data corresponding to the sum of the second residual data reconstructed by the frequency domain inverse transform unit **113**. In particular, the residue inverse transform unit **114** generates first residual data corresponding to the sum of the second residual data for each of the Y component, Co component, and Cg component in the YCgCo color space using Equation Set (3) below.

$$t=\Delta^2 G'-(\Delta^2 R'>>1)$$

$$\Delta G'=\Delta^2 R'+t$$

$$\Delta B'=t-(\Delta^2 B'>>1)$$

$$\Delta R'=\Delta B'+\Delta^2 B' \quad \text{Equation Set (3)}$$

Here, ΔX' denotes reconstructed first residual data and Δ^2X' denotes reconstructed second residual data.

Alternatively, the residue inverse transform unit **114** generates first residual data corresponding to the sum of the second residual data for each of the R component, G component, and B component in the RGB color space, using Equation Set (4) below.

$$\Delta G' = \Delta^2 G'$$

$$\Delta R' = \Delta^2 R' + \Delta G'$$

$$\Delta B' = \Delta^2 B' + \Delta G' \quad \text{Equation Set (4)}$$

Here, $\Delta X'$ denotes reconstructed first residual data, and $\Delta^2 X'$ denotes reconstructed second residual data.

The adder **115** generates a reconstructed picture corresponding to the sum of the predicted pictures generated by the motion compensation unit **104** or the intra prediction unit **106** and the first residual data generated by the residue inverse transform unit **114**. For example, the adder **115** generates a reconstructed picture in the YCgCo color space by calculating the sum of the predicted pictures for the Y component, Co component, and Cg component generated by the motion compensation unit **104** or the intra prediction unit **106** and the first residual data generated by the residue inverse transform unit **114**. Alternatively, the adder **115** generates a reconstructed picture in the RGB color space by calculating the sum of the predicted pictures for the component, G component, and B component generated by the motion compensation unit **104** or the intra prediction unit **106** and the first residual data generated by the residue inverse transform unit **114**.

The filter **116** improves the quality of the reconstructed picture by smoothing distortion at block boundaries in the reconstructed picture generated by the adder **115**. However, the filter **116** is not used for a high bit rate moving picture because high frequency components are likely to be lost.

Although the moving picture coding apparatus in FIG. **1** uses a scheme of adaptively applying a color space and a single mode scheme, it is to be understood that a moving picture coding apparatus using one of the two schemes is also possible.

FIG. **7** is a block diagram of a moving picture decoding apparatus according to an embodiment of the present invention.

Referring to FIG. **7**, a moving picture decoding apparatus according to an embodiment of the present invention includes an entropy decoding unit **701**, a dequantization unit **702**, a frequency domain inverse transform unit **703**, a residue inverse transform unit **704**, a motion compensation unit **705**, an intra prediction unit **706**, an adder **707**, and a filter **708**.

The entropy decoding unit **701** reconstructs integer values by entropy-decoding an input bitstream output from, by way of a non-limiting example, the moving picture coding apparatus of FIG. **1**.

The dequantization unit **702** dequantizes the integer values reconstructed by the entropy decoding unit **701** to reconstruct frequency component values. In particular, the dequantization unit **702** reconstructs the frequency component values by multiplying the integer values reconstructed by the entropy decoding unit **701** by a quantization parameter.

The frequency domain inverse transform unit **703** transforms the frequency component values in the frequency domain reconstructed by the dequantization unit **702** into data in the color space used in the moving picture coding apparatus to reconstruct second residual data corresponding to the differences between the residual data for each of the color components constituting the color space.

The residue inverse transform unit **704** generates first residual data corresponding to the sum of the second residual data in the color space used in the moving picture coding apparatus that are reconstructed by the frequency domain inverse transform unit **703**. In particular, the residue inverse transform unit **704** generates first residual data corresponding to the sum of the second residual data for each of the Y component, Co component, and Cg component in the YCgCo color space, using Equation set (3). Alternatively, the residue inverse transform unit **704** generates first residual data corresponding to the sum of the second residual data for each of the R component, G component, and B component in the RGB color space using Equation Set (4).

The motion compensation unit **705** compensates for the motion between the current picture and the reference picture according to the inter prediction mode used in the moving picture coding apparatus. In other words, the motion compensation unit **705** compensates for the motion between the current picture and the reference picture according to inter prediction modes independently applied to the color components of the color space or an inter prediction mode commonly applied to all the color components of the color space.

In other words, the motion compensation unit **705** compensates for the motion between the current picture and the reference picture according to a single inter prediction mode commonly applied to all the color components. In particular, the motion compensation unit **705** generates predicted pictures for the current picture using motion vectors, which are independently applied to the color components in units of blocks that are independent for the color components. Alternatively, the motion compensation unit **705** generates predicted pictures for the current picture using a single motion vector, which is commonly applied to all the color components in units of blocks that are common to the color components. In other words, the motion compensation unit **705** generated predicted pictures for the current picture from the reference picture in units of blocks corresponding to the size of blocks commonly applied to all the color components using the motion vector commonly applied to all the color components.

The intra prediction unit **706** predicts blocks constituting the current picture from adjacent pixels in a picture reconstructed by the adder **707**, according to the intra prediction mode used in the moving picture coding apparatus, and generates predicted pictures constituted by the predicted blocks. In other words, the intra prediction unit **706** predicts blocks constituting the current picture from adjacent pixels in a picture reconstructed by the adder **707**, according to the intra prediction modes independently applied to the color components or a intra prediction mode commonly applied to all the color components, and generates predicted pictures constituted by the predicted blocks. In particular, the intra prediction unit **706** predicts blocks constituting the current picture from adjacent pixels indicated by the prediction direction used in the moving picture coding apparatus and generates predicted pictures constituted by the predicted blocks. In other words, the intra prediction unit **706** predicts blocks constituting the current picture from adjacent pixels indicated by the prediction directions, which are independently applied to the color components in units of blocks that are independent for the color components, and generates predicted pictures constituted by the predicted blocks. Alternatively, the intra prediction unit **706** predicts blocks constituting the current picture in units of blocks corresponding to the size of blocks commonly applied to all the color components, from adjacent pixels for each of the color components indicated by the prediction direction commonly applied to all the color components.

The adder **707** generates a reconstructed picture corresponding to the sum of the predicted pictures generated by the motion compensation unit **705** or the intra prediction unit **706** and the first residual data generated by the residue inverse transform unit **704**. For example, the adder **707** generates a reconstructed picture in the YCgCo color space by calculating the sum of the predicted pictures for the Y component, Co component, and Cg component generated by the motion compensation unit **705** or the intra prediction unit **706** and the first residual data generated by the residue inverse transform unit **704**. Alternatively, the adder **707** generates a reconstructed picture in the RGB color space by calculating the sum of the predicted pictures for the R component, G component, and B component generated by the motion compensation unit **705** or the intra prediction unit **706** and the first residual data generated by the residue inverse transform unit **704**.

The filter **708** improves the quality of the reconstructed picture by smoothening distortion at block boundaries in the reconstructed picture generated by the adder **707**. However, the filter **708** is not used for a high bit rate moving picture because high frequency components are likely to be lost.

FIGS. **8**A and **8**B are flowcharts of a moving picture coding method according to an embodiment of the present invention.

Referring to FIGS. **8**A and **8**B, a moving picture coding method according to an embodiment of the present invention includes operations performed in time-series in the moving picture coding apparatus of FIG. **1**. The descriptions of the moving picture coding apparatus with reference to FIG. **1** apply to the moving picture coding method in the present embodiment, and thus the descriptions thereof will not be repeated here.

In operation **801**, the moving picture coding apparatus selects a color space from among a plurality of color spaces based on the characteristics of a current picture.

In operation **802**, the moving picture coding apparatus determines whether to perform inter prediction or intra prediction. Operation **803** is performed for inter prediction, or operation **806** is performed for intra prediction.

In operation **803**, the moving picture coding apparatus selects inter prediction modes to independently applied to the color components constituting the color space selected in operation **801** or an inter prediction mode to be commonly applied to all the color components constituting the color space selected in operation **801**.

In operation **804**, the moving picture coding apparatus selects motion vectors to be independently applied to the color components constituting the color space or selects a motion vector to be commonly applied to all the color components constituting the color space according to the inter prediction mode selected in operation **803**.

In operation **805**, the moving picture coding apparatus generates predicted pictures for the current picture from a reference picture using the motion vector selected in operation **804**.

In operation **806**, the moving picture coding apparatus selects intra prediction modes to independently applied to the color components constituting the color space selected in operation **801** or a intra prediction mode to be commonly applied to all the color components constituting the color space selected in operation **801**.

In operation **807**, the moving picture coding apparatus selects prediction directions to be independently applied to the color components constituting the color space, or selects a prediction direction to be commonly applied to all the color components constituting the color space from among predicted directions for the color components, according to the intra prediction mode selected in operation **806**.

In operation **808**, the moving picture coding apparatus predicts blocks constituting the current picture from adjacent pixels indicated by the predicted direction selected in operation **807** and generates predicted pictures constituted by the predicted blocks.

In operation **809**, the moving picture coding apparatus generates first residual data corresponding to differences between the current picture and the predicted picture for each of the color components generated in operation **805** or **808**.

In operation **810**, the moving picture coding apparatus generates second residual data corresponding to differences between the first residual data.

In operation **811**, the moving picture coding apparatus transforms the second residual data in the color space generated in operation **810** into values in a frequency domain.

In operation **812**, the moving picture coding apparatus quantizes the values transformed in operation **811**.

In operation **813**, the moving picture coding apparatus generates a bitstream by entropy-coding the values quantized in operation **812** and outputs the bitstream.

In operation **814**, the moving picture coding apparatus reconstructs frequency component values by dequantizing the values quantized in operation **812**.

In operation **815**, the moving picture coding apparatus reconstructs the second residual data by transforming the frequency component values reconstructed in operation **814** into data in the color space.

In operation **816**, the moving picture coding apparatus generates first residual data corresponding to the sum of the second residual data reconstructed in operation **815**.

In operation **817**, the moving picture coding apparatus generates a reconstructed picture corresponding to the sum of the predicted pictures for the color components generated in operation **805** or **808** and the first residual data generated in operation **816**.

In operation **818**, the moving picture coding apparatus improves the quality of the reconstructed picture by smoothening distortion at block boundaries in the reconstructed picture generated in operation **816**.

FIG. **9** is a flowchart of a moving picture decoding method according to an embodiment of the present invention.

Referring to FIG. **9**, a moving picture decoding method according to an embodiment of the present invention includes operations performed in time-series in the moving picture decoding apparatus of FIG. **7**. The descriptions of the moving picture decoding apparatus with reference to FIG. **7** apply to the moving picture decoding method in the present embodiment, and thus the descriptions thereof will not be repeated here.

In operation **901**, the moving picture decoding apparatus reconstructs integer values by entropy-decoding the bitstream output from a moving picture coding apparatus such as, by way of a non-limiting example, that of FIG. **1**.

In operation **902**, the moving picture decoding apparatus reconstructs frequency component values by dequantizing the integer values reconstructed in operation **902**.

In operation **903**, the moving picture decoding apparatus reconstructs the second residual data corresponding to the differences between the first residual data constituting the color space used in the moving picture coating apparatus among a plurality of color spaces by transforming the frequency component values in the frequency domain reconstructed in operation **902** into data in the color space used in the moving picture coding apparatus.

In operation **904**, the moving picture decoding apparatus generates first residual data corresponding to the sum of the

second residual data reconstructed in operation **903** in the color spaced used in the moving picture coding apparatus.

In operation **905**, the moving picture coding apparatus determines whether to perform inter prediction or intra prediction. Operation **906** is performed for inter prediction, or operation **907** is performed for intra prediction.

In operation **906**, the moving picture decoding apparatus compensates for the motion between a current picture and a reference picture according to inter prediction modes independently applied to the color components constituting the color space or an inter prediction mode commonly applied to all the color components.

In operation **907**, the moving picture decoding apparatus predicts blocks constituting the current picture from adjacent pixels in a reconstructed picture according to the inter prediction modes independently applied to the color components or the single inter prediction mode commonly applied to the color components, and generates a predicted picture constituted by the predicted blocks.

In operation **908**, the moving picture decoding apparatus generates a reconstructed picture corresponding to the sum of the predicted pictures generated in operation **906** or **907** and the first residual data generated by the residue inverse transform unit **704**.

In operation **909**, the moving picture decoding apparatus improves the quality of the reconstructed picture generated in operation **908** by smoothening distortion at block boundaries in the reconstructed picture.

FIG. **10** is the results of a simulation test according to embodiments of the present invention.

As is apparent from Table **1001** and Table **1002** in FIG. **10**, in the simulation test, RCT and IPP were performed in a single prediction mode. The results were compared with the results of coding according to H.264/MPEG-4 AVC FRExt. JM9.3 reference software was used for the simulation test. The test conditions are as follows. Film and Viper sequences (1920×1088 @ 24 Hz, progressive) were used as a test material, the search range was 64, quantization parameters were 12, 18, 24, 30, and 36, the number of reference pictures, i.e., reference frames, was 3, an entropy coding scheme was CABAC, the RD-optimized mode selection was "ON", the GOP (Group of Pictures) structure was IBBP, and the number of slice groups was 1.

The methods used in the simulation test are as follows. IPP is a method according to an embodiment of the present invention using IPP and single mode prediction, RCT is a method according to an embodiment of the present invention using RCT and single mode prediction, RCT (FREXT) is RGB coding using YCgCo for residual color transform, and YCgCo is external YCgCo coding in which RGB input data are converted to YCgCo before being coded. In particular, to evaluate the fidelity of the reconstructed RGB images, the average of peak signal to noise rates (PSNR) of all the color components, i.e., the average of RGB components, was measured. The results are shown in Table **1001** of FIG. **10**. In addition, the PSNR gain in each of the methods over the YCgCo method at two high bit-rates (20 Mbps and 60 Mbps) appears in Table **1001**. As shown in Table **1002**, the results of Y PSNR in YCgCo domain with approximately equal fidelity for chroma channels were compared in order to isolate the effect on a luma channel (most important channel).

FIG. **11** is a graph comparatively showing the coding efficiencies of various methods according to embodiments of the present invention in a lossless mode.

In the near future, it will be important to support lossless and near-lossless video compression. In H.264/MPEG-4 AVC FRExt, lossless coding can be achieved by skipping frequency domain transform and quantization. The methods according to en embodiment of the present invention can be applied to lossless coding when frequency domain transform and quantization are skipped. As is apparent from FIG. **11**, the efficiency of the method using IPP and single mode prediction is highest in lossless coding.

FIGS. **12**A and **12**B are rate distortion (RD) curves obtained through simulation of embodiments of the present invention.

In this simulation, only intra coding was performed. In particular, to evaluate the coding performance when independent intra prediction modes are used, all the color components were treated as monochromatic images.

Embodiments of the present invention can be written as computer programs and can be implemented in general-use digital computers that execute the programs using a computer readable recording medium. In addition, the data structures used in the embodiments of the present invention can be written to a computer readable medium by various means.

Examples of the computer readable recording medium include magnetic storage media (e.g., ROM, floppy disks, hard disks, etc.), optical recording media (e.g., CD-ROMs, or DVDs), and storage media such as carrier waves (e.g., transmission through the Internet).

According to the above-described embodiments of the present invention, since residual data are generated according to a single prediction mode commonly applied to all the color components, the correlation between the residual data is high. As a result, the coding efficiency of moving pictures increases. In addition, according to the present invention, the coding efficiency of a moving picture can be increased using a single color space adaptively selected among a plurality of color spaces according to the characteristics of the moving picture. Furthermore, according to the present invention, the coding efficiency of moving pictures can be maximized by applying all the methods described above.

Although a few embodiments of the present invention have been shown and described, the present invention is not limited to the described embodiments. Instead, it would be appreciated by those skilled in the art that changes may be made to these embodiments without departing from the principles and spirit of the invention, the scope of which is defined by the claims and their equivalents.

What is claimed is:

1. An image decoding method comprising:

obtaining information about a color representation from a bitstream;

obtaining a prediction direction of a chroma component from among a plurality of prediction modes associated with a prediction direction of a luma component, wherein the plurality of prediction modes include a first mode in which the prediction direction of the chroma component is identical to the prediction direction of the luma component and a second mode in which the prediction direction of the chroma component is different from the prediction direction of the luma component;

obtaining a predicted image based on the prediction direction of the luma component and the prediction direction of the chroma component; and

reconstructing a current image by using a residue and the predicted image, based on the information about the color representation.

2. The method of claim 1, wherein the information about the color representation indicates a color space into which color components are represented;

color representation indicates a color space into which color components are represented.

* * * * *